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TABLES FOR POINT-SAMPLE CRUISING IN PONDEROSA PINE

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The tables presented in this publication are based principally on data that have appeared in two previous publications. These are: (1) Donald W. Lynch's "Effects of stocking on site measurement and yield of second-growth ponderosa pine in the Inland Empire," Intermountain Forest and Range Experiment Station Research Paper 56; and (2) W. H. Meyer's "Yield of even-aged stands of ponderosa pine," U.S. Department of Agriculture Technical Bulletin 630. Other sources of information are acknowledged in footnotes to the tables derived from them.

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The accompanying tables have been compiled to aid foresters in cruising ponderosa pine by the point-sampling method. Volume determination by this method is basically a two-step procedure: first, estimate basal area per acre; and second, convert basal area to volume by using the appropriate ratio of volume/basal area. Point-sampling procedures for accomplishing the first step are now familiar to most foresters. However, proponents of point-sampling recommend a variety of methods for converting estimates of basal area to estimates of volume. The choice of method depends on the precision desired and the character of the timber stands. In even-aged second-growth ponderosa pine stands, the cruiser can take advantage of the uniformity of the stand to select the appropriate ratio based on stand height, or a combination of height and diameter. However, in old-growth or uneven-aged stands, the average ratio must be obtained from a representative sample of trees in the stand.

The following tables are arranged in three classes according to the relative accuracy of the associated techniques for estimating volume. The first table provides "rule of thumb" estimates arrived at quickly with a minimum of observation and calculation. The next set, tables 2, 3, and 4, may well equal the accuracy of the last set in even-aged stands of second-growth, but do not provide the flexibility to fit a variety of stand structures. Accordingly, the last set, tables 5, 6, 7, and 8, requires the most detailed sampling and calculation procedures--but with correspondingly greater potential accuracy.

Conversion of gross to net volume and techniques for calculating timber quality data have been slighted in the literature. A later section of this paper describes a technique using the percentage distribution of tree volume (table 10) which simplifies these calculations.

In the construction of these tables, and in the suggestions for their use, the necessity for complicated weighting factors to allow for the nature of point-sampling probabilities has been largely avoided. Such averages as mean stand diameter, mean stand height, cull deduction, and quality yield are to be computed as simple arithmetic averages of the data collected by point-sampling. This simplification is made possible because the accompanying tables are based on averages so weighted that they correspond to unweighted averages of point-sample data. In fact, the averages obtained by variable plot cruising give better estimates of volume than do averages from sampling on a fixed area basis because the larger trees are given more weight in variable plot sampling than in using the conventional techniques. It is interesting to note that in the stands described in Meyer's normal yield tables, the mean diameter obtained from a direct average of point-sampled trees corresponds very closely to the average diameter of the dominant and codominant trees.

STAND VOLUME RATIOS

Tables 1 and 4 are stand volume tables expressed as the ratio of stand volume to total stand basal area. The basal area of the stand in trees 0.6 inch and larger is multiplied by the ratio from the table for the volume units desired to obtain the stand volume.

The use of total stand basal area to estimate board-foot volume of trees 10 inches d.b.h. and larger may seem strange. However, use of total stand basal area eliminates errors in estimating the minimum diameter to be tallied, simplifies in-growth calculations when determining growth, and provides a common base from which volume in all units--board feet, cubic feet, or cords--can be estimated. Little additional work is entailed to obtain total stand basal area because of the very nature of point sampling.

Ratios Based On Individual Tree Samples

In irregular or mixed-aged stands, the stand volume table approach may not prove flexible enough to give accurate volume estimates. In such stands, the volume/basal area ratio can be determined from a sample of the trees tallied for the basal area estimate. The lower diameter limit of the trees sampled for volume should coincide with that for the basal area estimate, or else the basal area count should be recorded separately for the trees smaller than the minimum size for volume determination. The sample selection should be such that every tree tallied for the basal area count has an equal probability of being selected for the volume estimate. One should measure tree height and diameter either on one out of every n trees or on all the trees at every nth sample point. He should then determine the volume/basal area ratio from table 5, 6, 7, 8, or 9 for each tree sampled. Then, he can multiply the arithmetic average of these ratios by the stand basal area to obtain stand volume.

Tree Volume Ratios According to Height

Volume/basal area ratios for a given tree height are nearly constant over a wide range of diameters. Thus, for rough estimates, table 5, which neglects tree diameters, can be used to obtain the board-foot volume/basal area ratio.

Use of such standard ratios lends itself nicely to making up cumulative volume tally sheets. Carow[1/] shows how such a sheet may be designed and used.

The average tree volume/basal area ratio for each height class divided by the height in logs is very nearly a constant. Thus, it is possible to dispense with keeping the field tally by height classes. Instead, the total number of

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1/ Carow, John. Quick cruising with the Bitterlich angle-count method and a cumulative tally sheet. Mich. Forestry Note No. 1, 2 pp., Oct. 1953.

logs in all the trees qualifying at each point is tallied. For second-growth ponderosa pine, the average number of board feet per log per square foot of basal area is 39, and for old-growth, 53 (table 5, last column). These ratios, multiplied by the basal area factor of the angle-gauge, multiplied by the number of logs counted at the point equal the volume per acre represented at that point.

For example, consider three 4-log trees, five 3-log trees, and two 2-log trees counted with a prism having a basal area factor of 10 at a point in a second-growth stand. The volume per acre indicated by this sample is:

$$(3\text{x}4) + (5\text{x}3) + (2\text{x}2) = 31 \text{ logs}$$
$$(31 \text{ logs})\ (10 \text{ sq.ft./acre})\ (39 \text{ bd.ft./log/sq.ft.}) = 12{,}090 \text{ bd.ft./acre}$$

Tree Volume Ratios by Height and Diameter

Estimating tree diameter further improves the accuracy with which the average volume/basal area ratio can be determined. However, accuracy of the diameter measurement has only a limited effect on the over-all volume estimate, and no effect on the total basal area estimate. Accordingly, ocular estimates of tree diameter in broad diameter classes are adequate for most purposes.

Tables 6, 7, 8, and 9 list the volume per square foot of tree basal area computed directly from volume tables in current use. Tables 6, 7, and 8 apply to second-growth timber, while table 9 applies to old-growth timber with quite different form and top diameters.

FIELD MEASUREMENTS TO ADJUST TABLES FOR LOCAL USE

These tables are based on recognized, widely used stand and volume tables. When large areas are being cruised, local peculiarities of taper and bark thickness should be compensating. As with any other volume table--form-class, composite, or species--measurements of taper and bark thickness must be made in order to use the table with any confidence on small areas, or on areas where peculiarities of form are suspected. The actual volume/basal area ratio determined from stem measurements of the timber being cruised should be plotted over the tabular estimate for each sample tree.[2/] A smooth curve (frequently a straight line) drawn through these points indicates the adjusted values to be used in place of the tabular values given herein.

2/ Plotting is simplified by using log-log graph paper.

DISTRIBUTION OF TREE VOLUME BY LOG POSITION

Cruisers frequently use tables of the proportional distribution of tree volume in the respective logs of that tree as an aid in estimating cull. With point sampling, such tables become indispensable both for cull and log grade determination. Table 10 contains the proportion of tree volume in each log position for ponderosa pine.

PROCEDURES FOR QUALITY AND CULL ESTIMATION

Consider a cruise design on which height, quality, and defect have been tallied on each tree at every nth sample point. In order to summarize these data on a per-acre basis, one needs to calculate the volume/basal area ratio for each kind of volume--gross and net, in each quality category. Then, when the total stand basal area as estimated by the variable plot cruise is multiplied by the volume/basal area ratio for each category, the stand volume per acre in that category is obtained.

Table 11 illustrates and explains the compilation of such data summarized from a field tally. In this example the effect of diameter on the volume/basal area ratio has been disregarded. If the diameter were to be considered, a similar summary would be prepared for each diameter class. Then the entries in line 1 of table 11 would be taken from table 6, 7, 8, 9, or their equivalent. By using taper tables for each diameter and height class, upper log diameters could also be estimated and their volumes collated and totaled by diameter classes.

The compilation technique outlined here utilizes the full power of the variable plot survey design. The data can be readily compiled on desk calculators, although on large scale surveys, electronic computers could be advantageously programmed following the same procedure.

SLOPE CORRECTION

Sloping plots can be tallied in two ways: (1) by modifying the critical angle so that a constant basal area factor is maintained, or (2) by keeping the angle gauge constant and changing the basal area factor for the sloping plot. The former method is very convenient for tree-by-tree correction when a wedge-prism is the angle gauge. The procedure is clearly explained by Bell and Alexander.3/ The latter method is simple to apply in gently rolling terrain where abrupt changes in slope are unlikely within the "plot" area.

3/ Bell, J. F., and L. B. Alexander. Application of the variable plot method of sampling forest stands. Oreg. State Board of Forestry Res. Note 30, 22 pp. 1957.

Table 12 lists the correction factors by which the basal area factor of the angle gauge is multiplied to correct for the slope at that point when the angle gauge is not adjusted for slope compensation. This table is taken from Grosenbaugh.[4/] It is reproduced here so as to be readily available for use in conjunction with the other tables in this publication.

DERIVATION OF RATIO TABLES

Table 1

Cubic feet ratios were taken from table 6 according to a height/diameter curve for Inland Empire second-growth ponderosa pine prepared by D. W. Lynch. Suitable converting factors from cubic feet to cords were then applied to obtain the cords/square foot basal area ratios.

Table 2

This table is based on data from 207 plots of second-growth (25-125 years of age) ponderosa pine in the Inland Empire measured by D. W. Lynch. Individual tree volumes were estimated from table 32, U.S.D.A. Technical Bulletin 630. The original plots consisted of a complete enumeration of all trees on a fixed area. Calculation of $\Sigma dbh^3/\Sigma dbh^2$ gave the variable plot mean diameter. From the height/diameter curve for each plot the height corresponding to this mean diameter was determined. The equation

$$\log {}^{V}/BA = -0.48089+1.07326 \log H -0.08795 \log D$$

accounted for 96.7 percent of the variation in the volume/basal area ratio. The standard error of estimate of the volume/basal area ratio is 0.4 percent.

Table 3

This table is derived from table 2 by applying a conversion from cubic feet to board feet-International 1/4-inch rule of the form:

$$\log \left(\text{100 bd.ft.}/\text{cu.ft.}\right) = a + {}^{b}/D^{2} + c\frac{H}{D^{2}}$$

This equation is based on that given by Lynch (1958) with constants adjusted for the transformed variables, D and H.

4/ Grosenbaugh, L. R. Better diagnosis and prescription in southern forest management. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 145, 1955.

Table 4

This table was derived from Meyer's ponderosa pine yield tables. Variable plot mean diameters were calculated from Meyer's stand tables as described for table 2.

Table 5

The most probable diameters for each log height were estimated from height/diameter curves and the corresponding ratios taken from tables 8 and 9. It is recognized that this entails an interchange of the dependent and independent variables. However, the change in ratios is gradual enough that little error is introduced thereby.

Tables 6, 7, 8, and 9

These tables were derived from the original tables referred to in their respective footnotes. They were derived by dividing each entry by the basal area in square feet corresponding to the d.b.h. This process can be used to adapt any suitable volume table to variable plot cruising. Ultimately, it will be more desirable to construct ratio equations directly from the original tree measurement data. For small-scale cruises, tables based on these equations would be used for compilation, while on large-scale cruises the equations themselves would be incorporated into the electronic computer program for analysis of the data.

Table 1.--Stand volume/total stand basal area for cubic feet and cords

Volume measures	Stand height[1/] (feet)											
	30	40	50	60	70	80	90	100	110	120	130	140
Cubic feet[2/]	11.0	14.6	18.3	21.8	25.4	29.0	32.6	36.2	39.7	43.3	46.0	48.0
Cords:												
Site II[3/]	--	.06	.14	.25	.30	.34	.38	.42	.46	.50	.54	.58
Site III, IV, V[4/]	.05	.14	.21	.27	.31	.35	.39	.43	.48	.52	.55	.59
Site VI[5/]	.10	.17	.24	.29	.33	.37	.42	.46	.51	.55	.59	.63

1/ Height of tree of mean diameter of trees selected by angle gauge.
2/ Cubic feet inside bark, including stump and tip.
3/ Sticks straight and smooth.
4/ Sticks straight and slightly rough.
5/ Sticks slightly crooked and rough.

Table 2.--Stand volume/total stand basal area for cubic feet[1/]

Stand diameter (inches)[2/]	Stand height[3/] (feet)										
	20	30	40	50	60	70	80	90	100	110	120
2	7.74	12.0	16.3	20.7	25.1						
4	7.29	11.3	15.3	19.5	23.7	27.9					
6	7.03	10.9	14.8	18.8	22.8	27.0	31.1	35.3			
8	6.86	10.6	14.4	18.3	22.3	26.3	30.3	34.4	38.6	42.7	46.9
10	6.72	10.4	14.1	18.0	21.8	25.8	29.8	33.7	37.8	41.8	46.0
12		10.2	13.9	17.7	21.5	25.4	29.3	33.2	37.2	41.2	45.2
14			13.7	17.4	21.2	25.0	28.9	32.8	36.7	40.6	44.6
16				17.2	20.9	24.8	28.5	32.4	36.3	40.1	44.1
18					20.7	24.5	28.3	32.1	35.9	39.7	43.7
20						24.3	28.0	31.7	35.6	39.4	43.2
22							27.8	31.5	35.3	39.0	42.9
Mean[4/]	7.40	11.0	14.6	18.3	21.8	25.4	29.0	32.6	36.2	39.7	43.3

1/ Cubic feet inside bark, including stump and tip of all trees 0.6" and larger d.b.h. (Individual tree volumes taken from table 32, U.S.D.A. Tech. Bul. 630.)
2/ Mean diameter of trees selected by angle gauge.
3/ Height of tree of mean diameter determined as above.
4/ Calculated from:

$$\log V/BA = -0.4133+0.9858 \log H.$$

Table 3.--Stand volume/total stand basal area for board feet, International 1/4-inch rule[1/]

Stand diameter (inches)[2/]	Stand height[3/] (feet) 20	30	40	50	60	70	80	90	100	110	120
6	0.36	1.02	2.58	6.08	13.69	29.95	64.05				
8	2.84	6.16	11.8	21.0	35.8	59.2	95.8	152.5			
10	7.15	13.7	23.1	36.3	54.6	79.7	113.9	159.9	221.8		
12		20.8	32.8	48.3	68.0	92.9	124.2	163.2	211.7	271.3	
14			40.3	57.1	77.2	101.4	130.2	164.4	205.0	252.6	308.7
16				63.3	83.5	106.9	133.9	164.8	200.3	240.5	286.6
18					88.4	111.2	136.9	165.6	197.8	233.5	273.5
20						113.1	137.4	164.2	193.7	225.8	261.2
22							138.2	163.6	191.3	221.0	253.3

1/ For trees 10" and larger d.b.h. to a variable top. (Individual tree volumes taken from a table developed for use by the Forest Survey in the Intermountain Region.)

2/ Mean diameter of trees selected by angle gauge.

3/ Height of tree of mean diameter determined as above.

Table 4.--Stand volume/total stand basal area for board feet Scribner rule[1]

Stand diameter (inches)[2]	Stand height[3]									
	50	60	70	80	90	100	110	120	130	140
8	15									
10		40	40							
12		68	70	73						
14			100	105	113					
16			130	132	138	147	158			
18				158	158	167	182	200		
20					172	183	198	216	235	
22						200	213	230	248	267
24								245	262	281

1/ Volume of trees 12" and larger d.b.h. to an 8" top. (Individual tree volumes taken from table 34, U.S.D.A. Tech. Bul. 630.)

2/ Mean diameter of trees selected by angle gauge.

3/ Height of tree of the mean diameter determined as above.

Table 5.--Board foot/basal area ratios of ponderosa pine trees by height in 16' logs. Scribner rule

Timber age	Logs per tree								Mean per log
	1	2	3	4	5	6	7	8	
Second growth[1]	37	75	110	152	195	240	285	335	39
Old growth[2]	60	102	150	212	270	330	385	440	53

1/ Top diameter 6" to 9". Most probable ratios taken from table 8 below.

2/ Top diameter 8" to 25". Most probable ratios taken from table 9 below.

Table 6.--Second-growth ponderosa pine cu.ft./B.A. ratios[1/]

D.b.h. (inches)	Total height (feet)													
	20	30	40	50	60	70	80	90	100	110	120	130	140	150
4	9.2	13.8	17.2	21.8	25.3									
6	8.7	11.7	14.8	18.4	21.4	24.5	28.1							
8		10.6	14.0	17.2	20.3	23.8	27.2	31.5	34.4					
10		10.6	14.1	17.4	21.1	22.9	28.4	32.1	36.7	40.4	44.0			
12			14.0	17.8	21.7	25.5	29.3	33.1	36.9	40.8	44.6			
14			14.0	17.8	21.5	26.2	29.9	33.7	37.4	41.2	44.9	48.6	52.4	
16			14.3	18.6	22.2	25.8	30.1	33.7	37.2	41.5	45.1	48.7	51.6	54.4
18			14.7	18.7	22.6	26.0	30.0	34.0	37.3	41.9	45.3	48.7	52.1	55.5
20			14.7	18.8	22.9	26.6	30.3	33.9	38.1	41.7	45.4	49.1	52.3	55.5
22				18.6	22.7	26.5	30.3	34.1	37.9	41.7	45.1	48.9	51.9	55.3
24				18.8	22.6	26.4	30.6	34.1	37.9	41.4	44.9	48.1	51.6	54.4
26				19.0	22.8	26.6	30.4	33.9	37.7	41.2	44.4	48.0	50.4	53.9
28					22.9	26.6	30.4	33.6	37.4	40.9	44.2	47.4	50.5	53.5
30					22.8	26.5	30.1	33.6	37.1	40.3	43.6	46.9	49.7	52.8
32					22.5	26.1	29.9	33.3	36.5	39.7	42.8	46.0	48.7	51.5
34					22.2	26.2	29.5	33.0	35.9	39.0	42.1	45.1	47.6	50.1
36						25.7	29.1	32.5	35.4	38.3	41.0	44.0	46.4	48.6
38						25.4	28.8	32.0	34.8	37.6	40.0	42.8	45.2	47.5
40						25.2	28.4	31.4	34.1	36.8	39.0	41.7	44.0	46.3
42							28.0	30.8	33.5	36.0	38.1	40.6	42.8	45.0
44							27.5	30.1	32.8	35.1	37.2	39.6	41.7	43.8
46								29.5	32.1	34.3	36.3	38.6	40.6	42.6
48								28.8	31.3	33.5	35.4	37.5	39.5	41.4
50								28.2	30.6	32.7	34.5	36.6	38.4	40.3

1/ Total volume inside bark including stump. Basis: table 32, U.S.D.A. Tech. Bul. 630.

Table 7.--Second-growth ponderosa pine, bd.ft. (Scribner)/B.A. ratios[1/]

D.b.h. (inches)	Total height (feet)											
	40	50	60	70	80	90	100	110	120	130	140	150
10	18	18	37	37	55	55	73	73	92			
12	26	51	64	76	102	127	140	153	178	191		
14	37	56	75	103	122	140	168	187	206	225	243	
16	43	72	86	115	129	150	172	193	215	244	258	287
18	51	74	96	119	136	164	192	209	232	260	283	306
20	55	78	101	124	147	170	202	220	243	266	293	316
22		80	102	129	155	178	205	227	254	280	307	337
24		83	105	134	159	185	210	236	264	290	318	347
26			111	138	163	187	214	244	271	295	322	350
28			112	138	164	192	220	248	273	297	322	346
30			114	141	165	196	222	249	273	295	320	340
32			114	143	170	197	222	247	270	292	313	333
34			117	144	173	197	222	244	267	287	308	327
36				147	174	195	221	242	262	281	301	320
38				148	174	193	218	239	258	277	294	313
40				149	172	191	215	234	253	271	289	307
42					170	189	211	230	248	266	284	301
44					167	187	206	225	243	260	277	293
46						183	203	221	238	255	271	285
48						179	198	217	233	249	265	279
50						176	194	212	228	243	259	272

1/ Volume to 8" top. Basis: table 34, U.S.D.A. Tech. Bul. 630.

Table 8.--Second-growth ponderosa pine (Site IV), bd.ft. (Scribner)/B.A. ratios1/

D.b.h. (inches)	Number of 16' logs									
	1	2	3	4	5	6	7	8	9	10
8	57.3	143	229							
10	36.7	101	165							
12	31.8	76.4	134	185						
14	23.4	65.5	112	168	215					
16	17.9	60.9	104	158	204	258				
18	17.0	56.6	99	147	201	252	306			
20	13.8	52.7	99	144	195	245	296			
22	11.4	51.1	97	140	193	241	288	348		
24	11.1	50.9	95	140	191	237	286	342		
26	9.5	51.5	95	141	188	234	282	337	396	
28	9.3	51.4	93	140	187	234	281	334	388	
30	9.2	51.9	94	140	187	232	282	333	381	436
32		52.8	92	139	186	231	282	330	376	428
34			91	138	185	229	280	328	374	422
36			89	137	183	226	277	323	369	415
38			88	135	181	223	273	318	364	409
40			86	133	179	220	269	312	358	404
42			84	131	177	216	265	307	352	401

1/ 1.5' stump, 6"-9" top. Basis: table 35, U.S.D.A. Tech. Bul. 407.

Table 9.--Old-growth ponderosa pine tree volume (Scribner)/B.A. ratios

D.b.h. (inches)	Logs per tree								Top d.i.b.
	1	2	3	4	5	6	7	8	
12	64	115	153						7
14	56	103	140	206					8
16	57	100	143	186					8
18	62	108	142	187	226				9
20	69	124	156	193	243				10
22	80	136	174	208	250	288			11
24	83	146	191	223	258	293			11
26	87	152	203	233	266	298	342		12
28	89	159	210	243	271	308	343		12
30	92	163	220	255	283	314	346	383	13
32	93	163	224	265	293	326	352	385	14
34	94	167	232	273	303	333	363	387	14
36	96	168	238	283	312	344	373	396	15
38	96	169	242	286	322	354	382	405	17
40	96	171	245	292	330	362	389	412	20
42	97	171	248	296	336	371	397	426	25
44	98	175	248	299	341	379	407	436	28

Basis: RE-NRM
FOREST SURVEY
Ponderosa pine multiple volume table 1931 applicable to Region 1.
(Anderson-Ibenthal)
(Girard 1938)

Table 10.--Volume distribution in ponderosa pine trees1/

Log position in tree	Logs per tree						
	2	3	4	5	6	7	8
	Proportion2/						
Butt	0.62	0.47	0.38	0.32	0.28	0.25	0.23
2	.38	.34	.30	.27	.24	.22	.20
3		.19	.21	.20	.19	.19	.18
4			.11	.14	.15	.15	.15
5				.07	.09	.10	.11
6					.05	.06	.07
7						.03	.04
8							.02

1/ From C. A. Wellner and R. Hansen. Volume distribution in ponderosa pine trees. U.S. Forest Serv. North. Rocky Mtn. Expt. Sta. Res. Note 17, 1941.

2/ Proportion of gross merchantable volume (Scribner) by log position for ponderosa pine trees of indicated number of 16-foot logs per tree.

Table 11.--Explanation

Line 1. Volume/sq.ft. basal area ratios taken from table 5 (second-growth) or its equivalent.

Line 2. Ratio in line 1 multiplied by the proportions given in table 10.

Line 3. Represents a tally of the ratio of sound wood in each log of each tree tallied, recorded under their respective tree height, log position, and log grade. Thus, a perfectly sound log is recorded by the entry 1.00; a total cull, by 0.00; etc.

Line 4. Records the count of trees represented in each column. Note that the entry in the total column counts each tree only once, irrespective of its number of logs. Hence, the eight 3-log trees contribute only 8 to the total of 25 trees tallied.

Line 5. Equals the sums of data in line 3.

Line 6. Equals line 2 multiplied by line 4.

Line 7. Equals line 2 multiplied by line 5.

Line 8. Equals $100\left(1-\frac{\text{line 7}}{\text{line 6}}\right)$.

Line 9. Comprises the data in line 7 sorted by log grade.

Line 10. Equals the sums of data in line 9.

Line 11. Equals line 10 $\div$ total number of trees counted.

Table 11.--Calculation of quality and cull sample data

Line																															
	Tree height (logs)	1			2						3									4											Total
1	Tree volume ratio	37			75						110									152											
	Log position	1			1			2			1			2			3			1			2			3			4		
2	Log volume ratio	37			46.5			28.5			51.7			37.4			20.9			57.8			45.6			31.9			16.7		
	Log grade	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
3	Ratio of sound wood in each log tallied			0.90 .75 1.00 .50 .00		1.00 .95	0.90 1.00 .80 1.00 .15			1.00 1.00 .90 .70 .20 .90 .75	1.00	0.90 1.00 .95	0.50 .30 .80 .60		1.00 1.00 .95 .80	0.60 .50 .80 .90			1.00 .80 1.00 1.00 .90 .95 1.00 .75	1.00 1.00	1.00 .95 .85			1.00 .95 .85	0.90 1.00			0.85 1.00 1.00 .90 1.00			1.00 1.00 .80 1.00 .90	
4	No. of trees tallied			5		2	5			7	1	3	4		4	4			8	2	3			3	2			5			5	25
5	Total ratios sound wood			3.15		1.95	3.85			5.45	1.00	2.85	2.20		3.75	2.80			7.40	2.00	2.80			2.80	1.90			4.75			4.70	
6	Gross volume extension			185.0		93.0	232.5			199.5	51.7	155.1	206.8		149.6	149.6			167.2	115.6	173.4			136.8	91.2			159.5			83.5	2350.0
7	Net volume extension			116.6		90.7	179.0			155.3	51.7	147.3	113.7		140.2	104.7			154.7	115.6	161.8			127.7	86.6			151.5			78.5	1975.6
8	Cull percentage			37.0		2.5	23.0			22.2	0.0	5.0	46.0		6.3	30.0			7.5	0.0	6.7			6.7	5.0			5.0			6.0	15.9

$$\text{Net volume/sq.ft. basal area} = \frac{\text{Net volume extension}}{\text{Total no. of trees}} = \frac{1975.6}{25} = 79.02$$

$$\text{Gross volume/sq.ft. basal area} = \frac{\text{Gross volume extension}}{\text{Total no. of trees}} = \frac{2350.0}{25} = 94.0$$

Line		Grade 1	Grade 2	Grade 3	All grades
9	Net volume extension in each grade by log position	51.7 115.6	90.7 147.3 140.2 161.8 127.7	116.6 179.0 155.3 113.7 104.7 154.7 86.6 151.5 78.5	
10	Total grade out-turn	167.3	667.7	1140.6	1975.6
11	Net volume in grade/sq.ft. basal area	6.69	26.71	45.62	79.02

Table 12.--Appropriate correction factors for basal area or volume per acre calculated from unadjusted angle-gauge tallies taken on a slope, where slope percent is measured at right angles to contour

Limits of percent slope	Slope correction factor	Limits of percent slope	Slope correction factor	Limits of percent slope	Slope correction factor
10.0		55.8		80.7	
	1.01		1.15		1.29
17.4		57.8		82.3	
	1.02		1.16		1.30
22.5		59.8		83.9	
	1.03		1.17		1.31
26.7		61.7		85.4	
	1.04		1.18		1.32
30.4		63.6		86.9	
	1.05		1.19		1.33
33.6		65.4		88.4	
	1.06		1.20		1.34
36.6		67.2		89.9	
	1.07		1.21		1.35
39.5		69.0		91.4	
	1.08		1.22		1.36
42.1		70.8		92.9	
	1.09		1.23		1.37
44.6		72.5		94.3	
	1.10		1.24		1.38
47.0		74.2		95.8	
	1.11		1.25		1.39
49.3		75.8		97.2	
	1.12		1.26		1.40
51.5		77.5		98.7	
	1.13		1.27		1.41
53.7		79.1		100.1	
	1.14		1.28		1.42
55.8		80.7		101.5	

Correction factor for steeper slopes is:

$$\sqrt{1 + \left(\frac{\text{Slope percent}}{100}\right)^2}$$

Source: Grosenbaugh, L. R. Better diagnosis and prescription in southern forest management. U.S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 145, 1955.

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